

**INTERIM
ENVIRONMENTAL
GUIDELINES
FOR CULVERT DESIGN**

Department of Permitting Services
and
Department of Public Works and Transportation
Montgomery County, Maryland

April 1998

INTERIM ENVIRONMENTAL GUIDELINES FOR CULVERT DESIGN

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FOREWORD

Like many other jurisdictions during the last several years, Montgomery County has been attempting to deal with the issue of fish passage and fish blockages created where roadways or driveways cross streams. Many state and local regulators are at various stages of developing guidelines for design and construction of stream crossings. This set of guidelines is Montgomery County's endeavor to develop ways to prevent future impediments to fish passage at stream crossings.

Over the last several years, a committee composed of representatives from County, State, regional agencies, and engineering firms, have spent many hours discussing and defining roadway stream crossing guidelines. Valuable assistance was obtained from the peer reviews of these guidelines. It is the commitment of all those people that worked together which has made the Interim Environmental Guidelines for Culvert Design possible. These guidelines are written in a Interim Guideline format so that they may be revised as necessary when conditions or effectiveness warrant updates.

We would like to thank the following organizations and staff for their efforts and work by serving on the committee or assisting to help complete this project:

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I. PURPOSE

An environmentally sensitive stream crossing utilizes environmental and biological information, with cost effective construction and maintenance design considerations which minimize environmental impacts to fish passage, wetlands, and natural habitat of the stream valley, while adhering to prescribed hydraulic criteria.

The purpose of this document is to establish a set of guidelines that facilitate the environmentally sensitive design of bridges and culverts for stream crossings. These guidelines are intended to provide the design engineer with criteria and information needed to choose an appropriate location and a suitable structure, while maintaining the natural integrity of the stream valley. It is also the endeavor of this document to coordinate the needs of other state and local regulatory agencies, but not to supersede their regulatory authority. All of the proper paths and requirements for submission of waterway and wetland construction permits will be followed.

II. STATEMENT OF GOALS

The goal of these guidelines is to provide methods for the design and construction of roadway stream crossings which overcome major problems experienced with past roadway construction design practices.

These goals are to:

- Eliminate the degradation of the stream habitat, aquatic life and water quality;
- Recognize and avoid the creation of physical blockages and impediments to the passage of fish and other aquatic life;

- Minimize the burden of infrastructure construction and maintenance for County taxpayers; and
- Coordinate and unify the requirements and needs of the various regulatory agencies involved in the environmental review of roadway stream crossings.

III. APPLICABILITY

These guidelines may apply to all roadway projects which intend to cross streams with a perennial flow or streams with intermittent flow in defined channels identified by United States Geological Survey (USGS) maps, Maryland-National Capital Park and Planning Commission topographic maps, or the current Natural Resources Conservation Service (NRCS) soil survey maps.

IV. SITE INVENTORY

The site inventory should be performed at the same time the Natural Resources Inventory (NRI) is completed or as early in the design process as feasible. Because lot layout and project yield are contingent on the location of the streets the inventory should be completed prior to submission of the Preliminary Plan of Subdivision, for subdivision streets and County Master Plan approval (for County Master Planned Roads). Every effort must be made to find the best possible site for the stream crossing, see Section V. Assessment and mapping of the following natural resources are necessary in order to properly site a crossing:

- Existing stream channel geometry (cross-sectional and longitudinal)
- Width and depth and velocity of normal flow (base flow).
- Width, depth, and velocity of the bankfull storm event.
- Locations of wetlands and wetland type (i.e., forested, shrub/scrub, etc.)
- Location of steep slopes
- Location of high quality forest
- Floodplain characteristics (geometry, slope, soils, etc.)

- Stream bed and stream bank composition

A site visit is necessary to gather baseline information for these factors. At a minimum the stream walk will include conducting a photographic inventory, completing habitat and biological assessments, while confirming soils, wetlands, steep slopes, and other factors. See Appendix B for a sample field inventory form.

V. STRUCTURE CHOICE AND LOCATION

The culvert crossing should be located on the stream where it will have the least short and long term impacts to the stream valley and its habitat. Whenever possible the culvert crossing must be located in a section of the stream where the bankfull storm event channel geometry can be maintained. Over sized, steep sloped, and/or perched pipes should always be avoided. When the stream valley is on a steep slope, bridge or bottomless arch with a constructed or natural channel are preferred to the use of a pipe. However, when a pipe must be used, it should be designed to lay on a similar gradient.

All designs will:

- Convey the flows generated by the fully developed, or as currently zoned, (which ever is denser) upstream drainage area for the 100-year storm event. The method for computation will vary depending on the use of the embankment structure. In general, if the culvert is a roadway crossing with a drainage area less than 400 acres the rational method will be used. However, if the drainage area to the culvert is over 400 acres or if a stormwater management pond is created by the crossing, then an accepted hydrologic model shall be used, such as the NRCS TR-55/TR20 method.
- Maintain the existing water depth (quantity) and velocity through the culvert for the normal flow channel.
- Provide for the unobstructed flow of the bankfull storm event, without increasing or decreasing velocity by more than 5%.

NOTE: The goal is to maintain the movement of the natural bed load material through the culvert.

- Avoid or minimize impacts to wetlands, seeps, springs, and other sensitive stream valley features.
- Consider the quality of the existing aquatic life in the stream and the impacts to the quality of the existing stream habitat .
- Support existing or targeted aquatic resource conditions.
- Maintain the natural or existing stream gradient and meander pattern.
- Cross the stream as perpendicular as possible.
- Anticipate the total disturbed area (footprint) necessary in the stream valley. This includes the staging area, material storage, stock and spoil piles, access routes, sediment control measures, such as traps, basins, earth dikes, etc.
- Be able to construct the crossing with a minimum of damage to adjacent areas.
- Consider the soils, sub-soils, and/or underlying rock/parent material.
- Anticipate the amount of stormwater discharge associated with the road and stream crossing.

VI. STRUCTURE SELECTION

When selecting the type of structure for a stream crossing, the following design parameters should be considered in addition to the site inventory information and location selection items:

- A. The structure design should minimize the impacts to the natural environment while minimizing stream bed/bank damage to the extent possible, by limiting grading, clearing or other disturbances, and replacing lost vegetation in kind after construction.
- B. Be practical in design considerations.

- C. The depth (Height) of Water above the invert of the pipe at the inlet end divided by the pipe Diameter (HW/D) shall not exceed 1.2 for the 100-year storm event.
- D. The discharge velocity at the end of a culvert (flood cells), for the 10 year storm event, must not exceed 10 fps, or the stream's natural velocity (which ever is greater), and may not exceed 5 fps at the end of the outfall stabilization. Depending on the erodability of the soils, it may be necessary to provide mechanical stabilization until the velocity of the water slows to 3.5 fps.
- E. The normal stream flow (base flow) should be determined:
1. The normal flow should be considered to be the average annual width, depth, and velocity of the normal flowing stream. Although the flows will vary from season to season, use field measurements to determine the flow width, depth, and velocity of the **EXISTING** average normal flow in the stream, and adjust the flow to the season.
 2. All pilot/lowflow channels, culverts, or cells should be designed to maintain the normal stream flow characteristics. Maintaining the stream's natural/normal flow width and depth through a low flow culvert or channel is a design feature critical to maintaining fish passage and stream stability. See Illustration #1.
 3. Where the natural channel, at the crossing, is severely impacted by excessive erosion or other degradation, a less degraded reference section of the stream or a similar stream may serve as a model for the crossing design.
- F. Rip rap should only be used in the stream channel bottom when it is necessary to avoid scour.
- G. Beyond those areas susceptible to scour, the use of appropriate bio-engineering techniques are the preferred methods of stabilization. See Section VIII.B.2.
- H. Consideration must be given to other environmental characteristics of the stream and watershed, i.e. special protection areas, stream use class, other sensitive areas as designated by the Federal, State, County, or Municipal Government Agencies.

- I. The economic feasibility of the various alternative structures outlined in this guideline shall be analyzed by the Consulting Engineer and that study forwarded to the reviewing agencies.

VII. TYPES OF STRUCTURES

Outlined below are suggested stream crossing designs and methods that provide the necessary environmentally sensitive crossing. The designer should utilize the crossing type that allows for the best maintenance of the natural stream flow characteristics. Also refer to Appendix A.

A. Bridges

Constructing a bridge to span an environmentally sensitive area may be the least impactful method and can result in minor stream impacts during construction. A bridge may be most effective when crossing a stream valley with steep side slopes or very wide meanders. Bridge construction should be included in the economic analysis of the roadway crossing and that information supplied to the reviewing agencies.

B. Bottomless Culvert (Arches, Etc.)

Where a stream with minimal meander passes through a work area, a bottomless culvert may be designed to reduce disturbance within the stream channel. The arch size and design must allow for the natural meander, and/or the construction of the low flow channel with scour protection inside the culvert. The following should be considered during the design of a bottomless structure.

1. Minimize the length of the culvert while still meeting required highway design standards. Provide notched weirs (usually concrete) across the inlet and outlet ends of the culvert. The weir notches should be sized to maintain the base flow of the stream at its normal width, depth and velocity. The invert of the notch will be set at the same elevation as the finished stream channel.
2. Scouring along the culvert footings and at the outlet must be investigated. In cases where scour is anticipated to be a problem, a pilot/baseflow channel will be designed and installed. The area from the base flow channel to the footings will be stabilized as needed to prevent scour in accordance with preferred methods explained in Section VIII. Refer to illustrations #1 and #2.

ILLUSTRATION #1

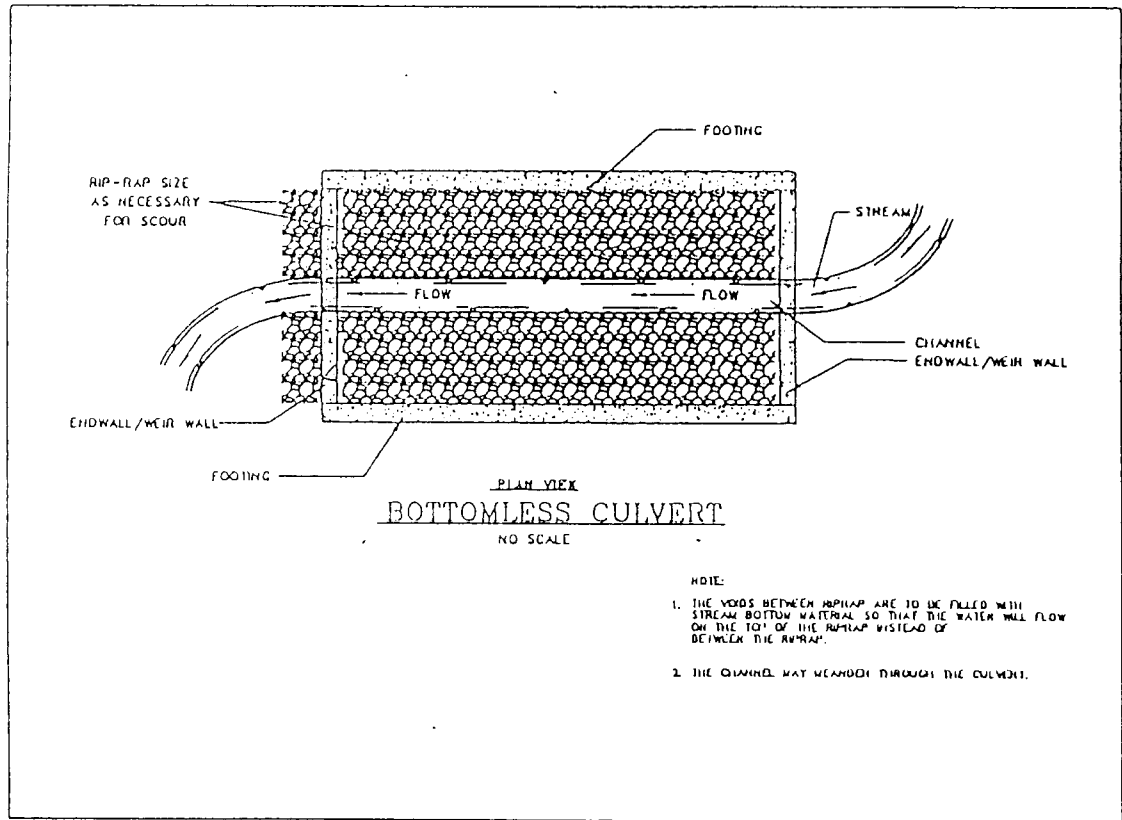
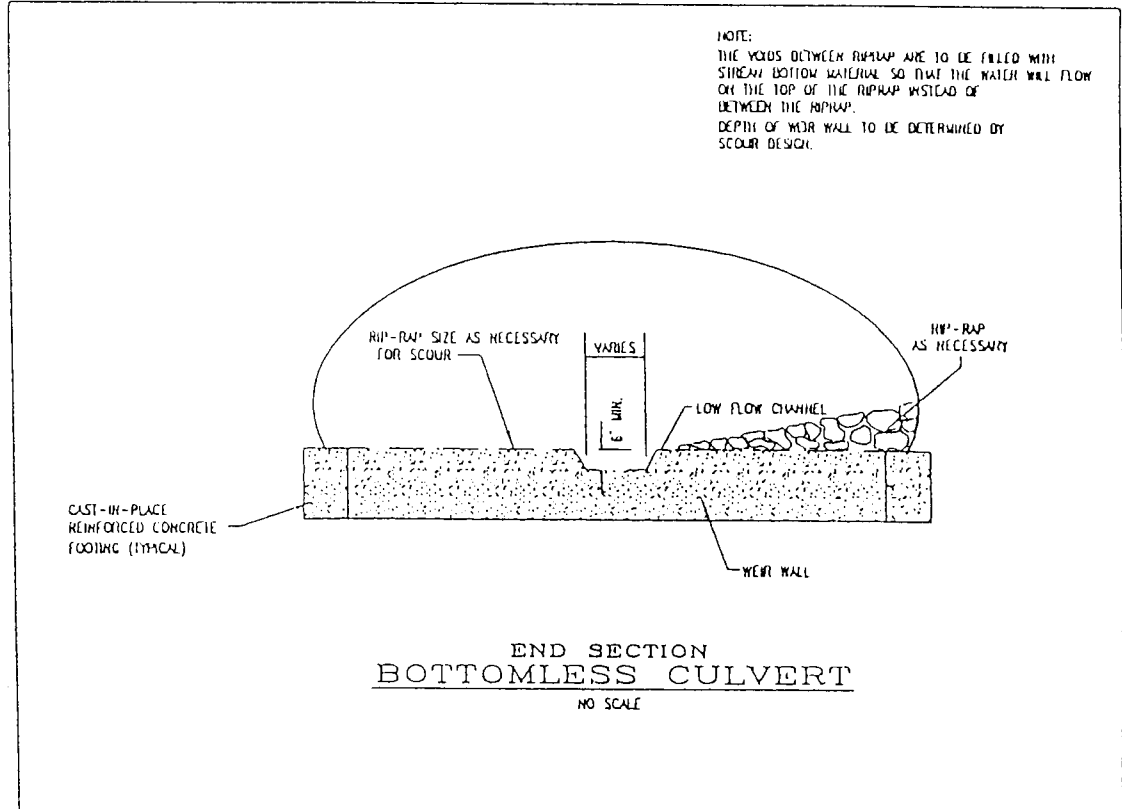


ILLUSTRATION #2



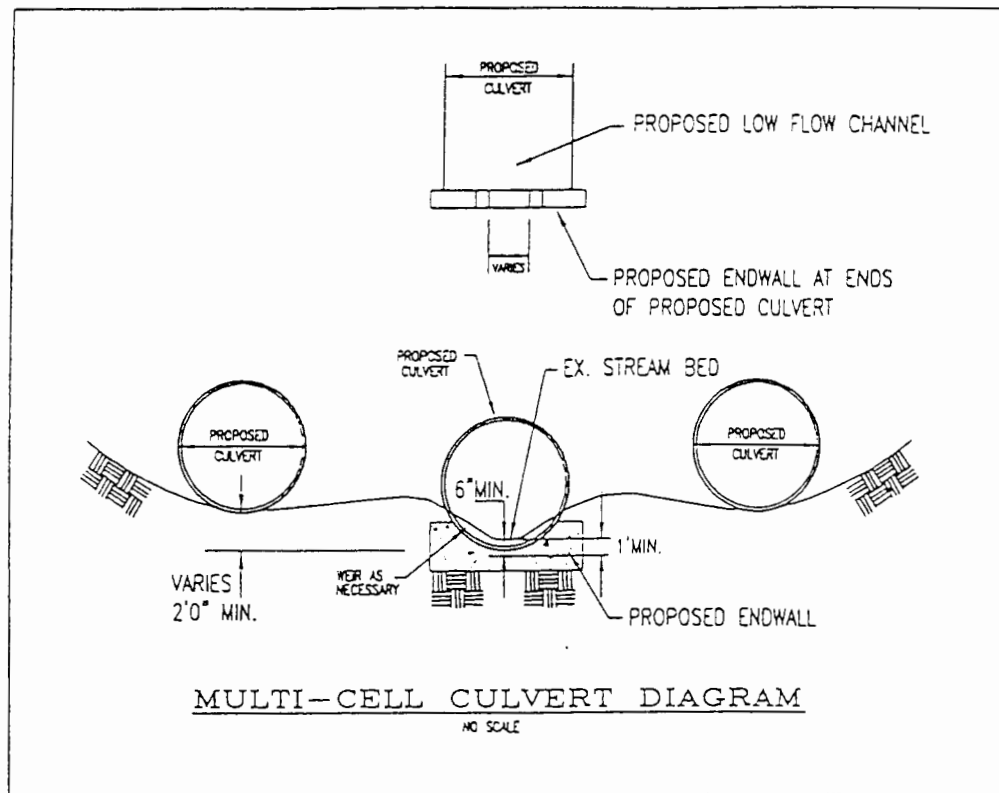
C. Multi-Cell Culvert

For the large drainage areas where the designer can no longer size the pipe to carry the storm flow by adjusting its invert to maintain the normal stream flow, a multi-cell culvert crossing may be used. The crossing will provide a single base flow culvert which is sized appropriately to facilitate the passage of aquatic life. One or more additional culverts will be provided for passing the flood storms. This type of structure should be used when the 100-year design storm culvert size exceeds the normal flow width of the stream.

1. Place the low flow (Pilot) cell within the stream, so that it follows the natural stream alignment as closely as possible.
2. Determine the flow depth, width and velocity of the existing normal flow in the natural stream channel. The low flow cell should be sized to maintain the stream's normal or natural flow width, depth, and velocity through the entire length of the crossing.
3. The low flow cell should be depressed six inches or more below the invert of the natural stream channel at both ends and weir walls shall be used as described in the single cell design.
4. As a minimum the flood cells should be placed at the elevation of the active flood plain adjacent to the stream. However, the invert elevation shall not be so low as to divert any of the normal stream flow away from the low flow cell. The flood cells may be placed on a slope different than that of the low flow cell in order to attain a 10 year outfall velocity for each cell of less than 10 feet per second.
5. The flood flow cells in combination with the low flow cell must be designed to pass all design storm flows. Refer to detail below.

ILLUSTRATION #3

(FOR ILLUSTRATION PURPOSES ONLY)



D. Single Cell Culvert (Small Drainage Areas)

A single cell culvert may be used where the design can address the following: pass the 100 year storm event with a HW/D equal to or less than 1.2, and maintain the normal the baseflow and bankfull storm event channel geometry with regard to width, depth, and velocity.

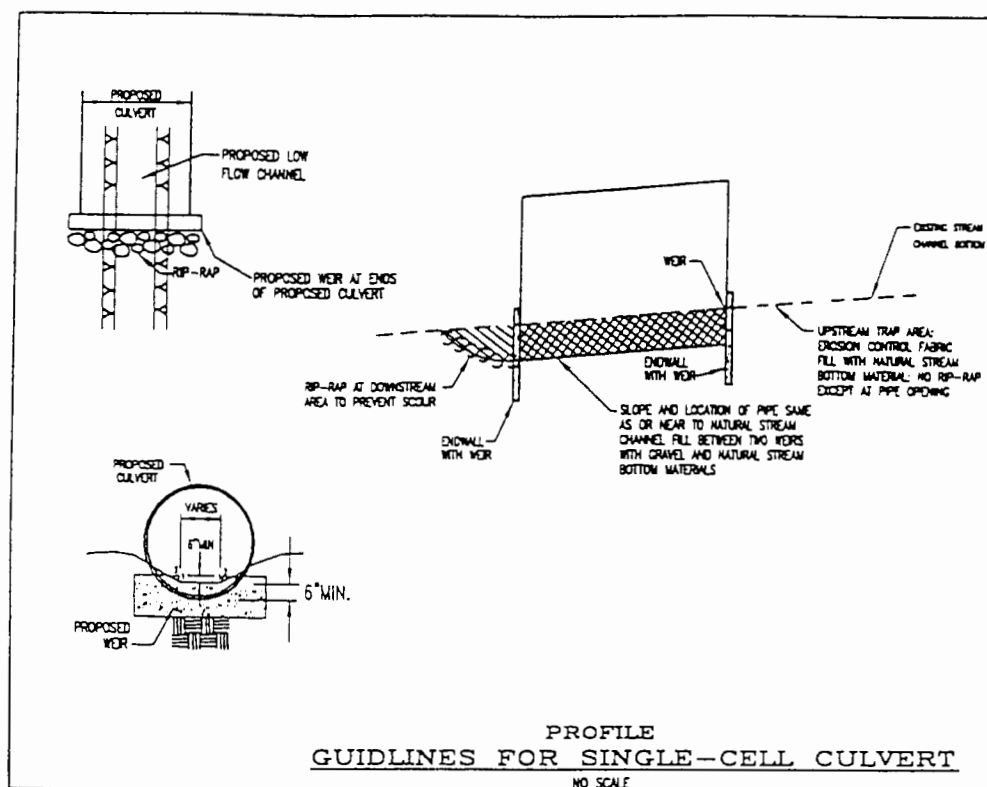
All culvert designs must incorporate the following features:

1. Locate the culvert within the stream valley so that it follows the existing and/or the natural stream alignment as closely as possible.
2. Unless specifically required or requested by an agency of the State, all inverts will be depressed a minimum of six (6) inches below the stream bed. Varying the amount of depression will allow additional flexibility in the design of the

culvert while maintaining the width and depth of the normal flow through the roadway crossing. The natural stream bed material shall be placed in the invert.

3. The slope of the culvert should equal, as closely as possible, the existing stream channel to provide for the normal movement of the natural bed load material through the culvert without it settling out.
4. Place a concrete weir at the entrance and at the outlet of the culvert pipe. The weir may have to have one, two, or more stages. The inverts of the baseflow weir shall be at the elevation of the finished stream bed. These weirs are placed to retain the deposition of stream bed material within the culvert, thus providing a natural surface in the bottom of the culvert. To prevent their displacement, the weirs should be designed as integral parts of the endwall. The area in between the weirs should be filled with native stream bed materials salvaged from the excavation for the culvert. If sufficient material can not be salvaged, material similar in size to the native stream bed material (such as bank run gravel) may be substituted. Where the pipe size prohibits the filling of the pipe invert, either by machine or by hand, the void space may be allowed to fill naturally with migrating bed load materials. When deemed necessary by any regulatory/reviewing agency they may require scour calculations.
5. Tree planting should be provided to shade the culvert's inlet and outlet channels. Planting shall be placed outside of the channel and only on the side of the channel that provides the most channel shading during the hottest portion of the day. The additional easement width required for access by maintenance equipment shall be provided on the opposite side of the channel from the plantings in order to ensure clear space for channel maintenance operations.
6. The alignment of all roadway crossings should be as perpendicular as possible to the stream in order to minimize areas of stream disturbance.

ILLUSTRATION #4



See Appendix A of this guideline for a chart summarizing the preceding structure information which can be used for quick reference.

VIII. TYPES OF INLET AND OUTLET STABILIZATION FOR ALL STRUCTURES

A. Location

Where possible, the crossing location should minimize the need to use rip-rap in the stream channel.

1. At the inlet of a single cell culvert, rip-rap within the stream channel should only be used when absolutely necessary, and then only immediately adjacent to the headwall. Other areas disturbed upstream of the inlet should be stabilized with soil erosion control fabrics and/or with native stream bed materials. Side slopes should be sodded or otherwise protected with vegetation. A concrete headwall with a footing of appropriate depth will be constructed to protect the roadway embankment from erosion due to scour.

2. At the outlet of a single cell culvert, rip-rap shall be used only when other methods employed to prevent scour of the stream channel are not practical. The size of rip-rap and length of rip-rapped channel or apron are dependent on the flow velocity of the 10-year storm. Side slopes of the stream channel should be rip-rapped to the top of the pipe(s). The slope of the rip-rapped channel should be as close to the natural stream channel as possible. The anticipated scour depth will be computed for the entire culvert as necessary. A concrete endwall with a footing of appropriate depth shall be constructed to protect the roadway embankment. The depth of anticipated scour will be calculated in accordance with the most current version of HEC-18, or other acceptable method approved by MCDPW&T and MCDPS.
3. For multi-cell installations, stabilization of the inlet and outlet ends of the low flow cell shall be accomplished in the manner outlined above for the single cell culvert. The inlet and outlet ends of the flood cell pipes shall be stabilized for the 10-year storm. This stabilization should be placed so that it does not extend into the stream channel.

B. Order of Preferred Instream Stabilization Techniques

Notes: 1. Any method used must provide for adequate public safety.

2. Each stream and stream bed is different and each crossing will be designed differently.

1. No Additional Stabilization: Quantity flow and velocity are proven to be non-erosive for a specific stream crossing.
2. Vegetative/Biological Stabilization: Velocity reduction and/or erosion control by the use of naturally occurring surface treatments only (i.e., grass, sod, and tree spikes). Vegetative/biological stabilization may be supplemented with stream restoration where the existing stream channel is to be returned to a more natural series of riffles, runs, and meanders, thereby decreasing the flow velocity.
3. Geo-textile Stabilization: Use to minimize erosion where vegetation can be planted and expected to grow through the material. The choice of a geo-textile for application must be consistent with its documented performance.

4. Rip-rap with low flow (pilot) channel: Use when design flow exceeds erosive velocity and stream channel degradation cannot be reduced by other methods.
 - a. The use of entrance rip-rap should be minimized or limited to only situations where substantial fill or cut must occur for the correct or necessary culvert alignment and to prevent head cutting.
 - b. The use of rip-rap at the outlet of a culvert should be limited. The length should be not more than what is necessary to attain a velocity below 5 fps for the 10 year storm event. Once this velocity is obtained the use of "natural" methods of preventing erosion and scour must be examined.
 - c. Whenever possible the pilot channel bottom should be on natural substrate. If necessary, a well anchored and appropriate geo-textile may be employed on the bottom of the low flow channel of an intermittent stream, where the natural substrate cannot withstand the designed velocity.
5. Rip-rap: The use of rip rap in the stream bed will be limited to those situations where the erosive velocity in the low flow channel cannot be reduced or compensated for by other means. In all cases when rip-rap is employed, the material used should be protected from increasing water temperature through solar heating by providing a means of shading or otherwise protecting it from direct sun exposure. All void spaces should be filled with soil excavated from the stream bed or material of similar size. The intent of this practice is to maintain the normal stream flow depth and velocity.

IX. MAINTAINING FISH PASSAGE WHERE GRADIENTS MUST BE STEEPENED

- A. Where or when the gradient needs to be steepened at the entrance end of the culvert, consideration should be given to providing a method that allows the fish to travel up the slope. A series of stepped pools may be acceptable. The naturally occurring resident fish species in the stream need to be determined during the design stage. The step or elevation changes should be limited to a height which those fish will normally navigate.

Natural materials should be considered for use, before structural materials are considered. MCDEP's or the Park's staff biologist may be able to help identify resident fish populations.

- B. Where, or when the gradient needs to be steepened at the outlet end of a culvert all of the preceding considerations should be reviewed. However, the design may need to incorporate the use of structural type devices such as log or concrete weirs, or large stones set in such a manner to allow the fish to swim up through the culvert.

X. GLOSSARY

- Active Floodplain:** The relatively flat or low land area adjacent to the stream channel subject to periodic, partial, or complete inundation by the stream at a recurrence interval of about two years or less.
- Bank Full Flow:** The water flow or discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediments, forming or removing bars, forming or changing bends and meanders and generally doing work that results in the average stream channel. (Dunne & Leopold 1978) Preliminary calculations may use the 1 year storm event to approximate the bankfull flow, which will then be field verified.
- Base Flow:** See **normal flow**.
- Bed Load Material:** The sediment, sand, pebbles, rocks, boulders, etc., which are components of the stream channel, that normally move down stream during a bank full storm event.
- Channelization:** The practice of straightening a waterway to remove meanders and make water flow faster.
- Culvert:** A structure under a roadway or embankment that allows water to pass.
- Drainage area:** The area of land draining to a given point in a watershed.
- Entrenched Channel:** The down cutting of a stream channel caused by erosion of the stream bottom during peak flow times. An entrenched channel may not have any flood plain above the top of the stream bank.
- Environmentally Sensitive Areas:** Areas having beneficial features to the natural environment, including but not limited to: steep slopes; habitat for Federal and/or State rare, threatened, and endangered species; 100-year ultimate floodplains; streams; seeps; springs; wetlands, and their buffers; priority forest stands; and other natural features in need of protection.

Gradient or Slope:	Slope calculated as the amount of vertical rise over horizontal run.
Habitat:	The area or environment in which an organism lives.
Headcutting:	The natural down-cutting of the stream bed to a lower elevation.
Hydrology:	The study of the properties, distribution and effects of water on the Earth's surface, soil, and atmosphere.
Incised Channel:	See Entrenched Channel .
Intermittent stream:	A stream that has interrupted flow or does not flow continuously.
Meander:	A circuitous winding or bend in a stream, creek, or river.
Normal Flow:	The water flow that is derived from natural storage (i.e., groundwater outflow and the draining of lakes, pond, swamps or other sources outside the net rainfall that create surface runoff); discharge sustained in a stream channel, not a result of direct runoff, and without the effects of regulation, diversion, or other works of man. It is also referred to as low, sustaining, base, ordinary, or groundwater flow.
Perennial Stream:	A stream that flows continually.
Reference Stream Section:	A stream or a portion of a stream selected to define a reference condition for a water body, that represents a minimally damaged stream of similar characteristics.
Riffle:	A shallow section in a stream where water is breaking over rocks or other partially submerged organic debris and producing surface agitation.
Rip-rap:	Stones of varying size used to stabilize stream banks and other slopes.
Run:	The straight fast-moving section of a stream between riffles.

Scouring:	The erosive removal of material from the stream bed and banks.
Stream bank:	The portion of the channel cross section that restricts lateral movement of water at normal water levels.
Stream Geometry:	Includes all physical characteristics of a stream; gradient, meander, riffles, runs, pools, banks, baseflow, floodplain, and soils.
Stream Order:	Represented by numbers 1st, 2nd, or 3rd; these numbers relate directly to the number of stream channels that come together to form a stream at any given location.
Stream Sinuosity:	The ratio of the channel divided by the valley length. It may be approximated as valley slope divided by channel slope. It indicates how a stream/river has adjusted its slope to that of its valley, or to changes in its channel dimensions or morphology.(Rosgen 1994)
Substrate:	The mineral or organic material that forms the bed of the stream.
Watershed:	An area of land that drains into a particular river or body of water. Usually divided by topography.
Wetland:	Those areas of land that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support , and under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

Appendix A

Design Selection Considerations	Types of Structures	Design Criteria
<ul style="list-style-type: none"> First Order Streams and Multi-Gradient Streams: Avoid multi-cell designs Change designs when one design does not effectively maintain natural baselaw channel and safe hydraulics. If normal stream cross-section geometry can be maintained (width, depth, normal velocity) in a depressed large sized pipe, then a single cell may be appropriate Use multi-cell when: design storm orifice exceeds existing normal flow channel width 	All designs	<p>Upstream of the culvert, place a limited area of rip-rap immediately adjacent to the head wall only. Any streambank areas upstream of the culvert that have been disturbed should be stabilized with vegetation and soil erosion fabric; any excavated area of the stream channel should be filled back in with natural stream bottom material.</p> <p>In order to reduce the amount of streambank armoring and minimize need for rip-rapping the upstream invert, place the culvert within the stream so that it follows the natural, existing stream alignment and gradient as closely as possible.</p> <p>At each of the upstream and downstream ends of the culvert, place a 1 foot high weir wall to help trap and maintain a natural substrate in the structure (the 1 foot height of the weir assumes a finche depression of the pipe invert, weir may be part of end wall footer in the stream bed)</p> <p>Pipe Weir wall to be placed on both ends and the upstream end will be back filled with existing stream substrate and limited amount of rip-rap immediately adjacent to the headwall. rip-rap at the outlet should be choked and limited to what is necessary for a 5 fps or less velocity, and geo-textiles used, where possible, for disturbed areas with velocities less than 5 fps</p> <p>Within the pipe, the area between the two weirs can be filled with gravel and/or the natural stream channel material (preferred). Small pipes can be allowed to fill in naturally.</p> <p>Box: Provide a low flow channel, depressed placement to avoid low flow channel filling in.</p>
	Single-cell design	<p>Pilot cell (in multi-cell) should be sized to maintain the normal stream geometry as to width, depth, and normal velocity of the natural stream channel, with same normal flow channel width and slope as natural channel. Pilot cell should be depressed at least 12 inches below the invert of the natural channel.</p> <p>Flood cells should be placed higher up than the pilot cell, at the floodplain elevation adjacent to the stream. The slope of each flood cell may be flatter than the pilot cell in order to attain a 10-yr outfall velocity of less than 10 fps. The flood cells in combination with the low flow cells must be designed to pass all design storm flows.</p> <p>Pilot channel should be a minimum of 75% of the existing stream normal (i.e. active) flow channel width, but not more than 100%.</p> <p>There should be 2 feet (min.) difference between the inverts of the low flow pipe and the flood flow cells (Pipes).</p>
	Multi-cell design	<p>Provide weirs (usually concrete) across the inlet and outlet ends of the culvert, with weir notches sized to maintain the normal stream flow in terms of width, depth and velocity. Low-flow channel should have natural substrate. Armor stream banks to maintain the location of the channel and prevent scour.</p> <p>Use existing cross-section not wetted perimeter, to determine width of structure. Provide meandering channel within the structure if possible in order to replicate existing channel geometry.</p> <p>Footing depth and size will be based on scour computations and supporting soil bearing capabilities</p> <p>Full headwall should be used at the inlet and outlet to provide adequate protection of the roadway embankment</p>
	Bottomless arch	<p>Design of a bridge crossing should not proceed until concurrence is obtained from the Departments of Public Works and Transportation, and Permitting Services.</p> <p>Consider use of a split span to increase amount of sunlight reaching the streambanks on a wide bridge crossing.</p>
	Bridge	

Project Name:

Visit Date:

STREAM SURVEY FOR DESIGN OF BIO-SENSITIVE STREAM CROSSINGS

Stream Order (See APPENDIX C)	
STATE USE CLASS	
Use I & I-P	
Use III & III-P	
Use IV & IV-P	
Specially Designated	
STREAM QUALITY	
Biotic Community Quality (as determined by MCDEP staff or equivalent monitoring protocol)	
STREAM FLOW TYPE	
Ephemeral Or Intermittent Flow	
Perennial (Constant Flow)	
NORMAL (BASEFLOW) CHARACTERISTICS	
< 3 Months	
> 3 Months	
WATERSHED CHARACTERISTICS	
Fully developed	
Partially developed (Including Agriculture)	
Undeveloped	
FUTURE OR PROPOSED DEVELOPMENT	
< 8% impervious	
> 8% impervious (What percent?)	

STREAM BED CHARACTERISTICS	
Bed Materials: (Visual inspection)	
Cobble, Gravel, Sand, Silts	
Solid Rock, Hard clay, etc.	
Gradient:	
Shallow (< 2%)	
Moderate (.05 - 1.2%)	
Steep (> 2%)	
Planform:	
Meandering (Sinuosity < 1.5)	
Sinuuous (Sinuosity 1.2 - 1.5)	
Straight (Sinuosity > 1.2)	
Channel Bed Degradation (incised / non-incised)	
Valley Confinement:	
High (steep valley walls; relative narrow FP)	
Moderate (slight to moderate sloped valley walls; relatively wide FP)	
Low (no definable valley walls; broad FP)	
Wetland impact (Y or N)	
Type of Riparian Wetlands (forested, scrub shrub and emergent, absent)	
Specimen Trees Present (Y or N)	
Specimen Tree Species and Size	

FIELD NOTES:

APPENDIX C

PUBLICATIONS

1. Maryland Department of the Environment, 1994. 1994 Maryland Standards and Specifications for Soil Erosion and Sediment Control.
2. Maryland National Capital Park and Planning Commission, February 1997. Environmental Guidelines.
3. Montgomery County Department of Permitting Services, 1996. Draft Stormwater Management Manual for Montgomery County, Maryland.
4. Montgomery County Department of Public Works and Transportation, 1988. Storm Drain Design Criteria for Montgomery County, Maryland.
5. Rosgen, D. Wildland Hydrology Consultants. 1994. Applied Fluvial Geomorphology Manual.
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